Annual Conference of Postgraduate Studies and Scientific Research (Basic and Engineering Studies Board)
17-20 February 2012, Friendship Hall, Khartoum.

Software Process Improvement for Small to Medium Enterprises

Dr. Hisham M. Abushama

Computer Department, Faculty of Mathematical Sciences, University of Khartoum

Abstract: Many software Small and Medium Enterprises (SMEs) are playing a great part in the software production industries. Current standard Software Process Improvement (SPI) models are accused of being cumbersome when applied within the SMEs environment. The SMEs need to adapt to their environmental barriers and to meet the challenging business objectives facing SMEs. This has led to the need to develop a simpler SPI model that is more dynamic and flexible, i.e. not too rigid in comparison to current SPI models. Achieving business objectives is one of the important recipes for information Technology (IT) and business success. The standard SPI models such as Software Capability Maturity Model tend not to focus their software process on the organization business objectives. This research was setup to design a generic SPI process model and roadmap for SMEs that is tailored to the business objectives. In this process model the business objectives help derive the SPI programme. Its phases are kept simple in terms of activities and procedures to adjust to SMEs resource barriers. The process model and the roadmap were applied within four partner SMEs companies so far and the findings indicate that their software processes have successfully improved and this has contributed back into their business objectives.

Keywords: *Software Process Improvement, SMEs, Process Maturity, Capability Maturity Model*

المستخلص: العديد من شركات انتاج البرمجيات الصغيرة و المتوسطة تلعب دوراً كبيراً في صناعة وسوق إنتاج البرمجيات. النماذج القياسية الحالية لعملية تحسين البرمجيات (SPI) اتهمت بأنها مُرهقة من حيث متطلبات الموارد عند تطبيقها ضمن بيئة الشركات الصغيرة والمتوسطة. الشركات الصغيرة والمتوسطة تحتاج إلى التكيف مع حواجز بيئتها و كذلك تلبية أهدافها. فلذلك هنالك حاجه إلى تطوير نموذج أبسط لعملية تحسين البرمجيات(SPI). تحقيق الأهداف التجارية هي واحدة من الصفات الهامة لتكنولوجيا المعلومات (IT) ، ونجاح الأعمال. النماذج القياسية لعملية تحسين البرمجيات SPI مثل نموذج نضج قدرات انتاج البرمجيات (CMM) لا تاخذ فى الاعتبار اهداف الشركات. هذا البحث صمم نموذج لعملية تحسين برمجيات (SPI) عامة نموذجية وخارطة الطريق للشركات الصغيرة والمتوسطة والتي يتم تفصيلها مع اهدافها التجاريه. هذا النموذج مراحله مبسطة من حيث الأنشطة والإجراءات للتكيف مع تحديات موارد الشركات الصغيرة والمتوسطة. تم تطبيق هذا النموذج في أربع شركات صغيرة ومتوسطة حتى الآن ، وتشير النتائج إلى أن العمليات البرمجيه قد تحسنت وساهم النموزج فى تحقيق اهداف أعمالهم.

1. Introduction

As software systems become ever larger and more complex there is an increasing need for a well-understood and managed software development process, to ensure quality of the product, reduce costs and maximize productivity. This is true in the small to medium enterprises (SMEs) that represent a significant sector of the software industry, as well as in large companies. Over the last ten years a consensus has emerged that this is best achieved through an iterative process of evaluation and improvement of the software process. The Capability Maturity Model (CMM) [1] developed by the Software Engineering Institute, together with other models and standards such as SPICE [2] and BOOTSTRAP [3] provide frameworks and tools for software process improvement (SPI). Such models typically define the levels of process maturity through identification and assessment of various key attributes. Published studies from the US [4] and Europe [5] report substantial business benefits.

There are potentially large gains to be made within the industry by wider application of SPI, but as yet the use of models such as CMM within smaller organizations has been limited. There is general agreement that they cannot be applied unmodified to small organizations [6][7][8].

Some research has been carried out in order to determine what modifications must be made to the model to make it effective in these development environments. Johnson and Brodman [6] suggest that tailoring is needed in specific areas, including documentation, management, review, resources and training. Laryd *et al*. [7] propose a "Dynamic CMM" model, concentrating mainly on roles and responsibilities of individuals within the organization. In contrast, Horvat *et al*. [8] conclude that "major improvements can be achieved by improving the technical issue of the process instead of the organizational issue", and propose a model which integrates CMM with the ISO 9001 and ISO 9000-3 models. Richardson [9] proposes a generic model based on self assessment and use of a process/practice matrix, which helps to determine the importance of each practice within the software process, and hence set priorities for improvement.

Paulk [10] also concludes that "the issues associated with interpreting the software CMM for the small organization are different in degree but not in kind." Paulk also emphasizes the need to tie the SPI programme to the organization's business goals. However, there is no explicit mechanism for this in CMM.

Kautz [11] reports measurable business benefits even for very small enterprises using a flexible, tailored improvement approach.

Encouraging though these results are, many questions remain to be answered. Typically, SMEs operate within tight financial constraints. They require low-risk strategies which relatively quickly show results for

any investment of resources. Which generic model provides the most reliable way to achieve these results? Can risk assessment and minimization be factored into the SPI model? How can SPI be tailored to the organization's business goals? How can software measurement be used effectively within the SPI programme? How can the effectiveness of the SPI programme be assessed, so that managers can see the return on their investment?

The PISME (Process Improvement for Small to Medium Software enterprises) was set up in order to address some of these outstanding areas.

2. The PISME project

PISME is an action research project, with the author as a researcher working alongside managers and developers in participating companies advising and assisting with the planning and implementation of software process improvement programme. As well as this active involvement the author are currently using observation and informal discussion as methods of data collection about the projects; at later stages as projects mature the researcher will use more formal data collection techniques, including questionnaires and structured interviews.

Four companies are currently participating in the project, as can be seen from table 1 they cover a wide range of sizes and business areas. Three are independent software houses, and one continues to function independently as a software producer within a larger telecommunications group.

Table 1: Companies Participated in the Project

	Type of company	Business area	Total number of employees	Number of Software developers
Company A	Independent	Financial packages	250	52
Company B	Part of group	Telecommunications	35	11
Company C	Independent	Administrative systems	17	12
Company D	Independent	E-commerce	25	7

Working alongside the managers and developers in these companies for the past nine months, the researcher has begun to evolve an essentially pragmatic and (business) goal oriented SPI process model for SMEs.

3. The process model

The PISME process model is summarized in figure 1. The key features of the process are:

- The existing process, however informally defined, is examined, and, if resources permit an explicit model is created. (This often leads to heated discussion as different interpretations of the existing process specification are uncovered!)
- Early in the PISME programme the business goals are defined by management. These goals drive much of the subsequent activity, especially the selection and prioritization of key process areas for improvement, and the selection of measurements.
- A consultation exercise is carried out, involving all members of development teams. This is a useful exercise which plays to the strengths of small, flexible teams found in smaller organizations. A brainstorming session, and/or questionnaire-based survey helps the developers team to take ownership of the SPI programme, and to be involved in the programme from the earliest stage.
- A tailored version of the CMM assessment (see section 4) is carried out by the researcher, primarily to help identify key process areas (KPAs) for improvement. This also indicates the CMM level of the software process, which is often of less immediate usefulness to SMEs, but still useful as a baseline from which to measure future progress. This is in agreement with the observation of Paulk that "maturity levels should be measures of improvement not goals for improvement" [10].
- Using these inputs the KPAs for improvement are identified and prioritized. The main criteria here should be the extent to which the KPAs are likely to contribute to the identified business goals. One company has found a weighted selection approach of the type described by Martin [12] to be useful. The process/practice matrix approach described by Richardson [9] could also be used.
- Measurements are defined as an integral part of the SPI planning process. This activity is described in section 4.5.
- The SPI plan is periodically reviewed, and mechanisms are put in place to collect feedback from stakeholders

The researcher is involved mainly in the assessment and measurement definition activities. The researcher also review plans, and assist in putting in place data collection procedures. The following sections describe some of these activities in more detail.

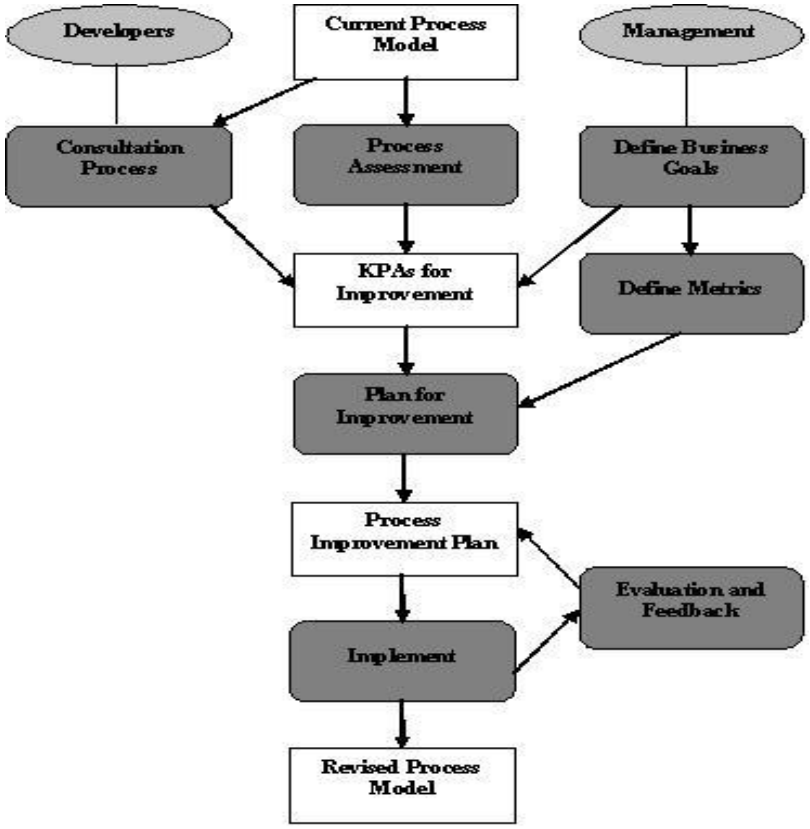

Figure 1: The PISME Process

4. PISME roadmap for process improvement.

As can be seen in Figure 2 PISME defined a road map for process improvement as follows:

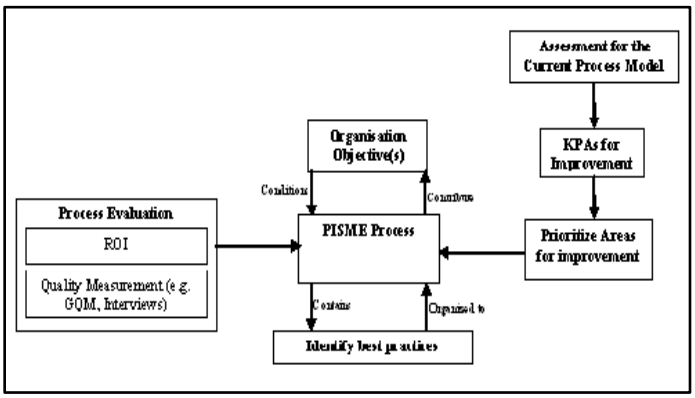

Figure 2: PISME Roadmap for Process Improvement

4. 1 Assessment for the current process model

Process assessment will be consisted of an awareness and business case workshop which focuses on process improvement, followed by a series of assessment interviews where different groups or individuals from them were met. The assessment is based on a modified and customizable version of the CMM assessment questionnaire. Emphasis was placed on meeting at least one top level manager as well as technical managers and members of the development teams.

This two-way process enhances communication and understanding. In particular, this clarifies the actual issues of people involved in the process improvement actions. The importance of having a process improvement champion who could take responsibility for overseeing the implementation of improvement actions was stressed.

Currently the assessment is carried out by the researcher involved in the project, but ongoing work is developing a web-based version to be used for self-assessment.

4.2 KPAs for improvements

The above assessment method will be used to identify KPAs or areas for improvement as weaknesses in the current SME software process.

4.3 Prioritize areas for improvement:

A Priority Matrix will be developed in order to prioritize KPAs that most contribute to the business objective. In order to do this, the practitioner will identify the business objectives within the individual SME. The priority matrix will then assess how much impact of each KPAs within the SME, that have been identified by the assessment method, to the business objectives. Besides that, the weighted criteria will be developed that will determine the rate or the weight of each KPA versus the business objective.

4.4 Identify best practices

For an organisation that wishes to embark upon an SPI programme, there are clear approaches-totally internal SPI such as PISME model and a framework-based SPI such as CMM. In the internal SPI, the current processes of the organization are analysed and depending on the shortcomings discovers and the goals of the SPI, Initiatives are taken for improvement. A framework-based SPI, on the other hand, uses an external framework against which process is analysed and which may be used to determine the course of action in the SPI initiatives.

At the early stage of PISME model emphasising on analysing the current process against KPAs in CMM ladder in order to identify opportunities for improvement. And then those opportunities act as SPI goals. Hence plan put in place to precede these goals. However, when SPI plan put in plan you need to know which practices that achieve the SPI goals and to help SPI implementation. Therefore this section suggests some practices to support KPAs that come in CMM level 2. The reason of doing up to level 2 because all the companies that participate in our research are not yet achieved level 2. However the researcher will continue suggesting practices for higher level when our partners reach level 2.

4.5 Process evaluation

Evaluation is an essential part of the PISME approach, and managers in the collaborating companies are keen to have more precise ways of tracking key resource and quality indicators.

Following the example of many authors, for example [13], the researcher use the Goal Question Metric paradigm [14], with the selection of attributes to measure based on the business goals defined for the SPI programme.

The most popular measurements are metrics for project tracking and monitoring, such as budgeted and actual cost of work packages completed, and those related to defect detection, for example number of reported defects per KLOC of delivered code. In our experience the most important aspects of measurement for SPI programmes in smaller organizations is that they are simple to gather and interpret, and that they are actually used in planning and decision making. Simple automation can help reduce the overhead associated with data collection and processing, but as one manager explained to us, he is unwilling to devote resources to automate the process until it has proved its usefulness.

It is also essential to put in place some baseline for measuring the effectiveness of the SPI programme, in order to ensure that adequate payback is being achieved and maintained. For this a simple model for return on investment is used, from Krasner (1990):

$$ROI_{(t+i)} = [old\ costs_t - new\ costs_{(t+i)}] / cost\ of\ improvements_{(i-t)} \quad (1)$$

where t is the time when costs were baselined, t+i is a later time when costs are re-measured, and i-t is the time interval over which improvement costs were spen

5. Results

We are still at an early stage of this project, so conclusions are necessarily tentative, and based on informal observation and discussion. All of the technical managers were very supportive of the idea of an SPI programme, and enthusiastic champions were found in all the companies. Business managers tended to be somewhat more sceptical, and will require evidence of payback before becoming fully convinced of the usefulness of this approach.

There was general acceptance and enthusiasm for a more quantitative approach, especially to project tracking and management. Measurement programmes, if kept as simple as possible and with clear relevance to business goals.

Where there is some reluctance on the part of developers to support the SPI programmes this has mainly been due to a perception that it increases the burden of documentation, and stops them “getting on with the job”. For this reason new documentation requirements should be kept to a minimum, kept as simple as possible, and phased in gradually. The purpose of the documentation should be made clear.

The researcher is currently developing a web integrated tool that support rapid process improvement and assessment. The assessment part of the tool used to identify opportunities for improvement in SMEs partners. The key features of the tool are to assess the current process model and to identify KPAs for improvement, identify best practices to support SPI implementation and evaluated the process improvement by the use of software metrics.

Company A is now well into the implementation phase of their SPI programme, and already report improvements in project tracking and maintenance of schedules. However more analysis will be needed to determine if this is in fact a direct result of the improvements initiated as part of the PISME programme.

7. Conclusion

A process model for SPI has been devised, specifically tailored for small to medium software enterprises. It emphasizes the importance of business goals for the selection of key process areas for assessment, senior management and developer involvement, and the use of quantitative measurements. The approach is currently being applied in four companies, with support from the research team. Two companies are

currently at the stage of defining KPAs for improvement, one is planning the SPI programme, and one has gone some way into implementation of the planned improvements. Although the project is still at an early stage the results so far are encouraging, especially in gaining the support of business and technical managers for an SPI programme. Early measurements in one company indicate progress, but this remains to be confirmed by more detailed analysis. Ongoing work is concentrating on quantitative evaluation of SPI programmes, and in developing the assessment method.

References

[1] Paulk, M., Weber, C., Curtis,B. and M.B. Chrissis, *The Capability Maturity Model: Guidelines for Improving the Software Process*, Addison-Wesley, 1999.

[2] El Emam, K., Drouin, J-N., and Melo, W. *SPICE: The Theory and Practice of Software Process Improvement and Capability Determination*, IEEE Computer Society Press, 2001.

[3] Kuvaja, P., Simila, L., Krzanik, L., Bicego, A., Koch, G. and Sankonen, S. *Software Process Assessment and Improvement: the BOOTSTRAP Approach*, Blackwell, 1994.

[4] Krasner, H. The *Payoff for Software Process Improvement: What it is and How to Get it*, IN: El Emam, K., and Madhavji, N. (eds.) Elements of Software Process and Improvement, IEEE Computer Society Press, 1999.

[5] Zahran, S. Software *Process Improvement: Practical Guidelines for Business Suc*cess, Addison-Wesley, 2001, see pp 390-398.

[6] Johnson, D. and Brodman, J. Tailoring the *CMM for Small Businesses, Small Organizations, and Small Projects*, Software Process Newsletter No 8, 1997.

[7] Laryd, A. and Orci, T. Dynamic CMM for Small Organizations, *Proceedings of the First Argentine Symposium on Software Engineering*, Tandil, 2001, Argentina.

[8] Vajde, R. Horvat, Rozman, I.,and Gyorkos, J. Managing the complexity of SPI in small companies, *Journal of Software Process: Improvement and Practice*, Vol. 5, 2000, pp 45-54.

[9] Richardson, I. Software Process Matrix: a Small Company SPI Model*, Journal of Software Process: Improvement and Practice*, Vol. 6, 2001, pp. 157-165.

[10] Paulk, M. Using the CMM in Small Organizations, The Joint 1998 *Proceedings of the Pacific Northwest Software Quality Conference and the Eighth International Conference on Software Quality*, Portland, Oregon, 1998, pp 350-361.

[11] Kautz, K. Software Process Improvement in Very Small Enterprises: Does it Pay Off? *Journal of*

Software Process: Improvement and Practice, Vol. 4(4), 1998, pp 206-226.

[12] Martin, S. Business Process Improvement, McGraw Hill, 2002

[13] Briand, L., Differding, C. and Rombach, H.D. Practical Guidelines for Measurement-Based Process Improvement, *Journal of Software Process: Improvement and Practice*, Vol. 2, 1996, pp 253-280.

[14] Basili, V. and Weiss, D. A methodology for collecting valid software engineering data, *Journal of IEEE Transactions on Software Engineering*, Vol. 10(6), 1984, pp 728-738.